INFLUENCE OF ATMOSPHERIC TEMPERATURE AND HUMIDITY ON THE VARIATIONS IN SEASONAL ABUNDANCE AND PHENOLOGY OF *MICRONECTA STRIATA* FIEBER[1]

T. C. Banerjee, A. S. Mondal and T. K. Nayek[2]

(*With seven text-figures*)

Catches of *Micronecta striata* F. in a light trap surrounding the Crop Research Farm were continually obtained at different seasons over twenty-one months. Numerical abundance during the different seasons varied consistently, leading to the occurrence of well-defined peaks in September 1978, and March, June and October 1979. The data were compared with the prevailing conditions of atmospheric temperature and humidity. Observed variations in local abundance and activity were fairly associated with the seasonal changes in both the parameters. Annual simple correlations were significantly negative ($P \leqslant 0.05$) with maximum temperature and indifferent with minimum temperature. More of the variations (59.01%) in the activity of *M. striata* were related to the changes in maximum relative humidity ($P \leqslant 0.01$) than that of the minimum one. Variance analysis suggested that a little alteration in the moisture content of the air during night might induce considerable changes in the activity of the species population.

Introduction

Seasonal variations in distribution and abundance of the tropical insects are largely conditioned by variations in the environmental parameters, particularly the weather that produces profound influence on the phenology of the species concerned (Dobzhansky and Pavan 1950, Andrewartha and Birch 1954, Williams 1961, Owen 1969, Gibbs and Leston 1970, Bigger 1976, Wolda 1978b). In such areas with six pronounced seasons, as most of eastern India, the numerical strength of insects decreases during summer and winter but, it increases during autumn and spring when the ecological conditions become favourable (Banerjee and Choudhuri 1980).

The local status and phenology of *Micronecta striata* Fieber in relation to tropical weather conditions are comparatively less known. This paper, attempts to consider the local abundance and phenology of the insect species, by means of a light trap, in relation to the tropical conditions of atmospheric temperature and humidity.

Material and Methods

The material of this investigation comprised the adults of a phototropic nocturnal insect, *M. striata* Fieber (Hemiptera: Corixidae) which was collected continually over twenty-one months (April 1978-December 1979) by a light trap in the Crop Research Farm, Uni-

[1] Accepted September 1980.

[2] Ecology Research Laboratory, Department of Zoology, University of Burdwan, Burdwan 713 104, West Bengal, India.

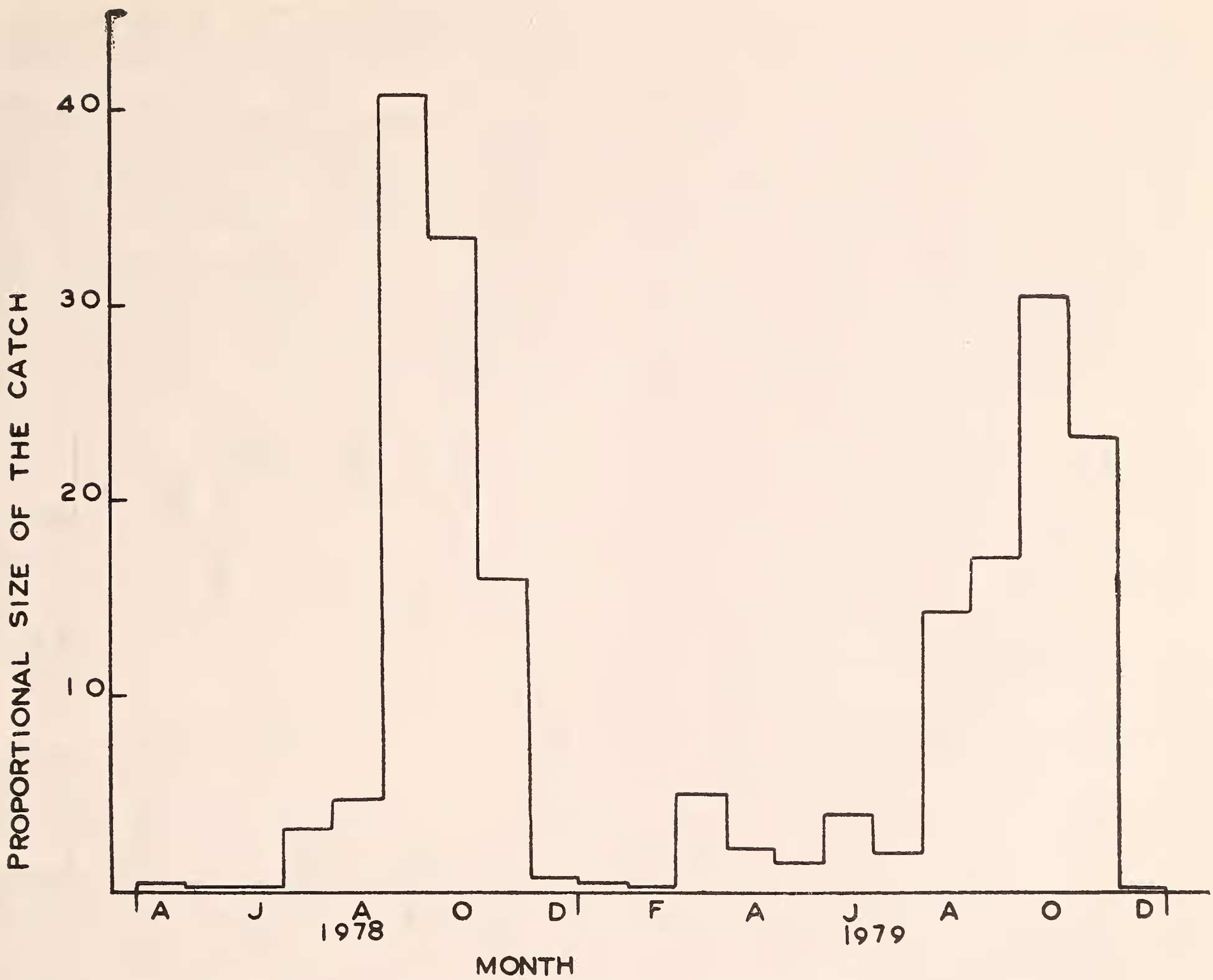

Fig. 1. Seasonal variations in distribution and abundance of the captures of *M. striata* in a light trap.

versity of Burdwan (23°16′N and 87°54′E). The insect is widely distributed and one of the most abundant species in the group. It lives submerged in water clinging with its hind legs to various objects (Popham 1943, Pruthi 1969) but swarms in the air for various biological activities.

Trapping covered the time between half-an-hour before sunset and half-an-hour after sunrise everyday. Certain unavoidable circumstances arising out of power failure, mechanical defects, etc., however, caused interruptions in the continuous trapping for 8 nights in 1978 and 14 nights in 1979. The numerical strength of the catch (i.e. local abundance X activity) differed from night to night probably due to the prevalence of variable weather conditions which produced occasionally considerably large or small collections. The five-day running mean was adopted to avoid swamping effects produced by the excess captures on the small ones.

The data on the seasonal variations in abundance and activity of the species population, as measured by the light trap catches, were maintained in the laboratory in the following morning and expressed as mean log catch ± 1 S.E. per night (Williams 1937, Beall 1938). This logarithmic transformation of the nightly capture made the assumed linearity more plausible since each transformation reduced the range of the variable concerned. In practice, one was added before taking logarithm of each of the dependent variable (i.e. log n+1) to mitigate any zero catch.

The influencing atmospheric environmental parameters considered for the study were the maximum temperature and minimum relative humidity of the day preceding the night of capture, and the minimum temperature and maximum relative humidity on the night of capture. These were taken by the Meteorological Branch at Burdwan under the Directo-

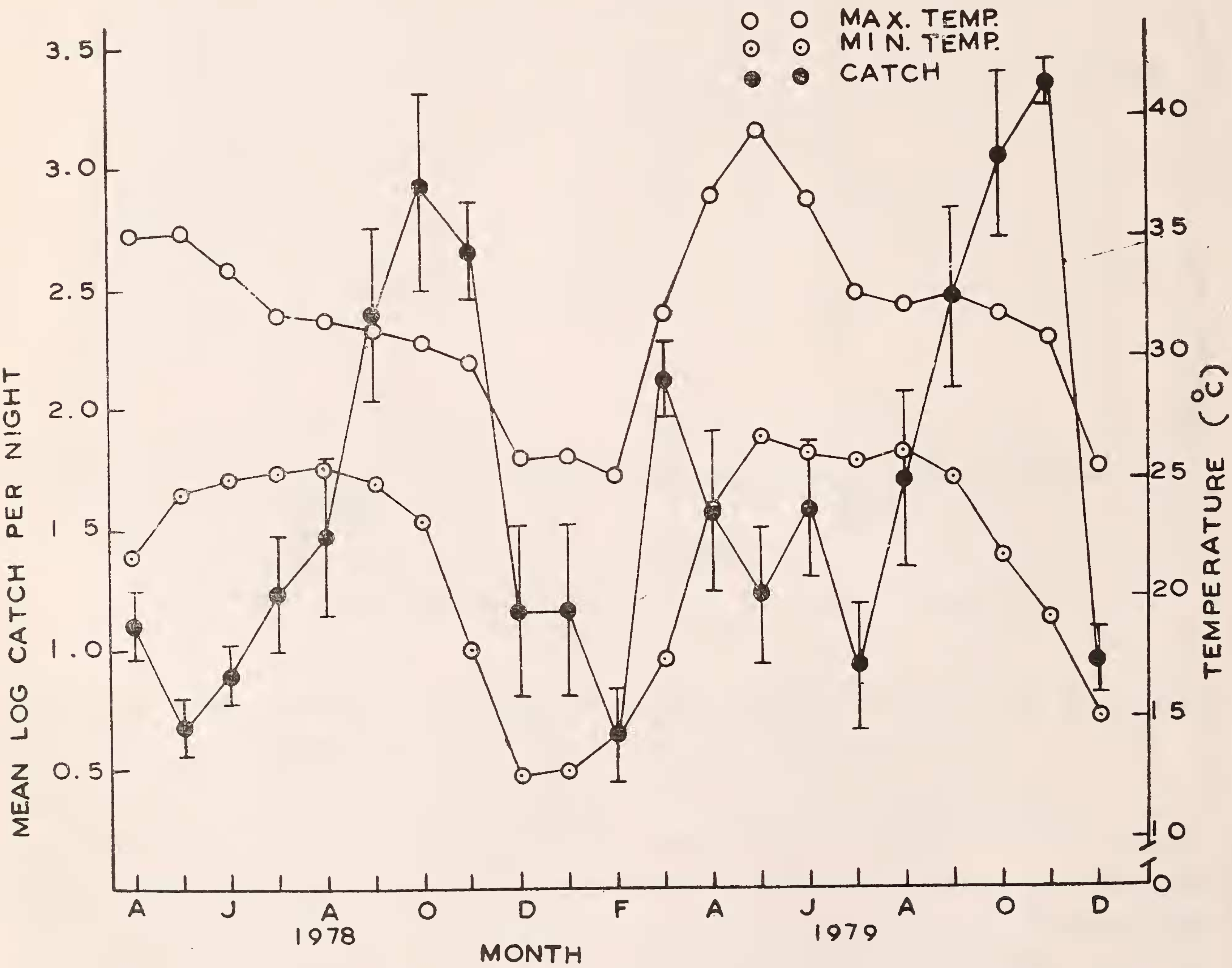

Fig. 2. Seasonal changes in abundance, as mean log catch per night, of *M. striata* against the corresponding changes in atmospheric maximum and minimum temperature (Vertical lines represent one standard error on either sides of the mean).

rate of Agriculture, Government of West Bengal, which operated a constantly recording thermo-hygrograph.

The correlation and regression co-efficients were worked out to enquire into the relations between the dependent and independent variables (Bailey 1959). The annual 'b' values were further employed to forecast the average amount of change in each weather factor that would precisely be required for a unit change in the dependent variable. Since the interpretation of such simple relationship was complicated by simultaneous relations existing within the matrix, the analysis of variance was resorted to for examining the extent of contribution made by each of the influencing parameters, so as to account for the total sum of squares of the deviations in the dependent variables.

Results

Variations in seasonal abundance:

It was observed that a collection of 745211 adult individuals of *M. striata* was continually caught over twenty-one months. The composition of the captures differed from 2 47 009 in 1978 to 4 98 202 in 1979. Figure 1 presents the variations in the local abundance of the insect, as indicated by the light trap captures, for each month sampled. The proportional capture shows the increase during September-October (40.7%-33.4%) in 1978 and September-November (16.9%-30.6%) in 1979.

Despite such increases, the numerical strength of the species population varied consistently, leading to the occurrence of well-defined peaks in September 1978, and March, June and October 1979. These peaks probably represent the abundance contributed by the cycling of life-processes of the species population in the locality, and increased local activity induced by the prevailing circumstances in which the catches occurred during those months.

Variations in activity in relation to temperature:

The variations in the seasonal abundance, as mean log catch per night, in relation to recorded changes in temperature parameters, have been presented in figure 2. The swamping effects, produced by occasional excess captures resulting in substantial change in the proportion on three and two nights in September 1978 and October 1979, respectively, were reduced by the treatment of running logarithmic mean. It would, thus, be noticed that the peaks were shifted from September to October 1978 and October to November 1979 (cf. Fig. 1).

The larger values in the curve during October 1978, and March, June and November 1979 indicated associations between the activity of the insect species resulting in higher captures and the respective maxima and minima of take-off temperature that ranged from 30.86°C to 23.68°C, 31.98°C to 18.64°C, 36.56°C to 25.91°C and 30.86°C to 19.22°C. In spite of such associations, the seasonal variations in phenology ought not to be considered as the only contribution of temperature parameters. Still, much of the variations in the occurrence of such events might be ascribed to the changing influence of ambient temperature conditions of the plots during certain months.

The correlation and regression coefficients between the temperature parameters and the captures of *M. striata* have been presented in table 1. The 'r' values with maximum temperature were significantly positive in August, September and December 1978, and in February and December 1979. Similarly, the 'r' values with minimum temperature were significantly positive in December 1978, and February, September and December 1979; and negative in July 1979. Besides, the average 'r' value for 1978 was significantly negative ($P \leqslant 0.05$) with maximum temperature; whereas, two years' average correlations were insignificantly positive with regard to both the parameters.

The linear relationship between the captures of the insect and the temperature parameters

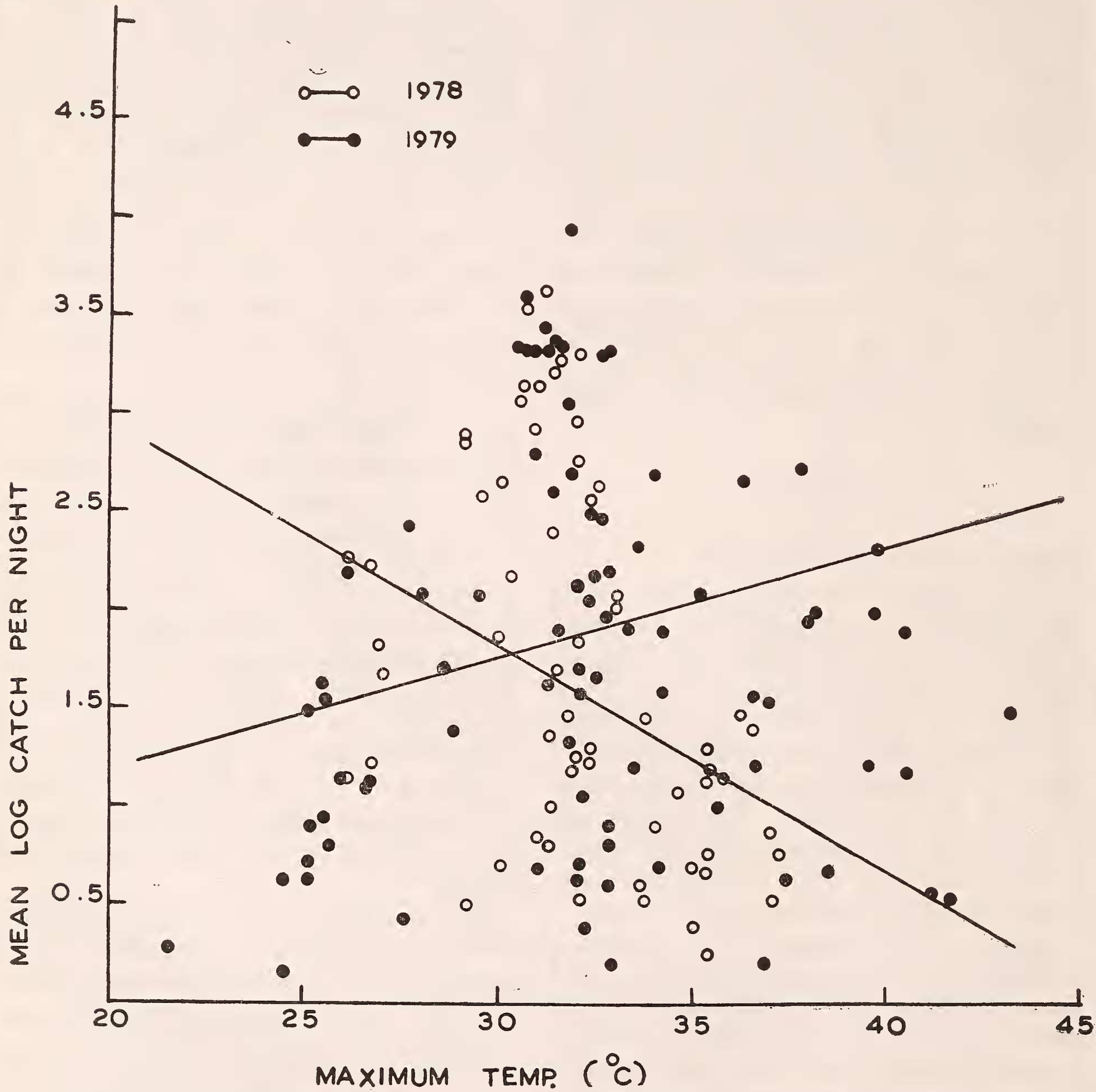

Fig. 3. Scatter diagram with regression lines showing relationship between the captures of *M. striata* and atmospheric maximum temperature (for 1978, Y = 5.2833-0.115 x and 1979, Y = 0.5936 + 0.0355 x).

may also be shown graphically in the form of scatter diagrams (Figs. 3 and 4). The slope of the fitted lines in each diagram indicated respective regression constants for maximum temperature (—0.115 for 1978 and 0.0355 for 1979) and minimum temperature (—0.012

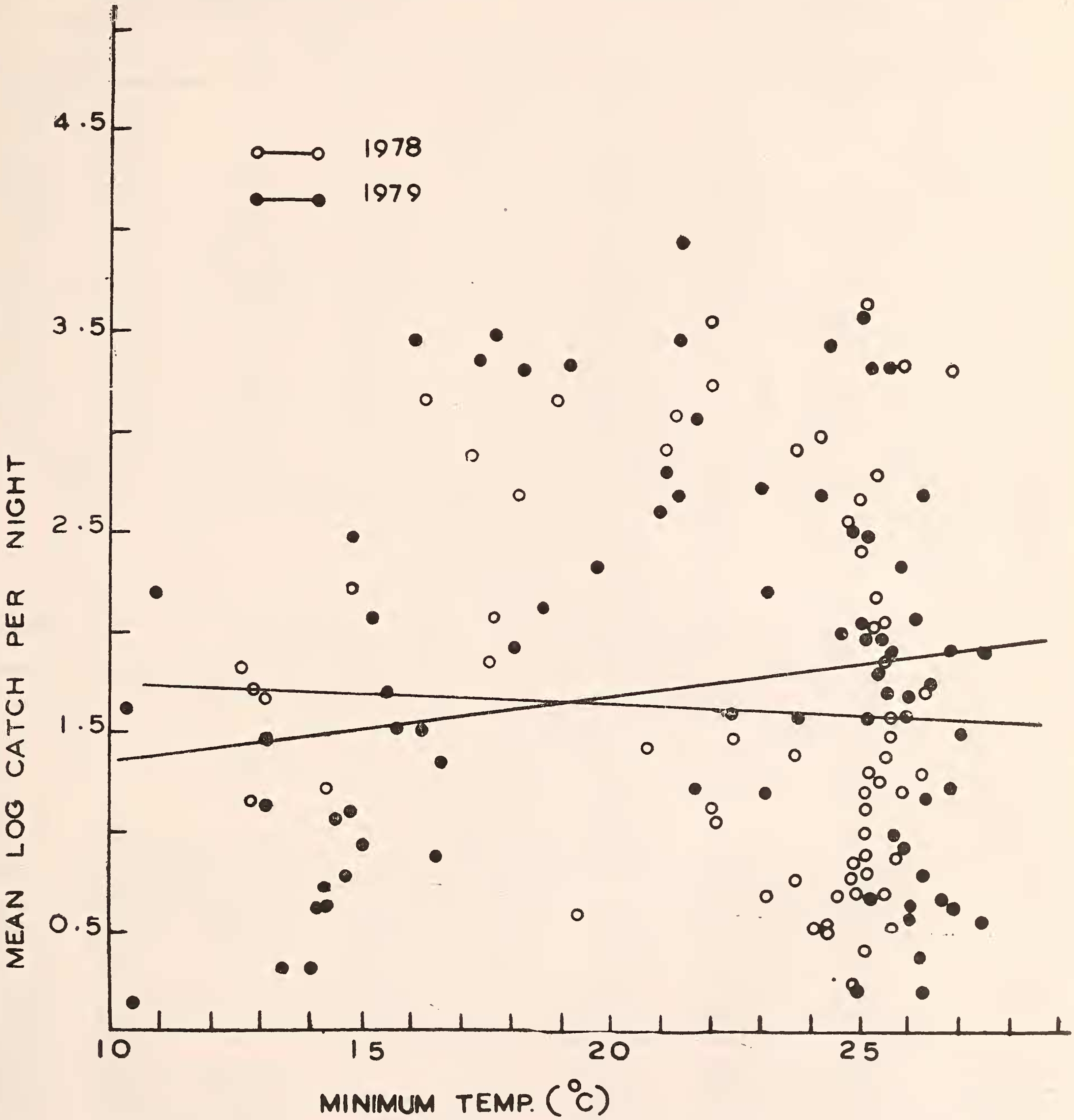

Fig. 4. Scatter diagram with regression lines showing relationship between the captures of *M. striata* and atmospheric minimum temperature (for 1978, Y = 1.8878 — 0.012 x and 1979, Y = 1.0778 + 0.0304 x).

TABLE 1

CORRELATION AND REGRESSION COEFFICIENTS BETWEEN THE CAPTURES (LOG N+1) OF *M. striata* AND THE ATMOSPHERIC MAXIMUM AND MINIMUM TEMPERATURES

	Maximum temperature (°C)				Minimum temperature (°C)			
	1978		1979		1978		1979	
	Corr.	Reg.	Corr.	Reg.	Corr.	Reg.	Corr.	Reg.
January	—	—	0.5377	0.4593	—	—	–0.1658	–0.0560
February	—	—	0.7191*	0.1327	—	—	0.9404***	0.3829
March	—	—	0.1395	0.0183	—	—	–0.0281	–0.0040
April	0.1278	0.0314	0.3869	0.2014	0.3160	0.0684	–0.1036	–0.0660
May	0.1942	0.0467	0.1762	0.0867	0.3010	0.1067	–0.3614	–0.4115
June	–0.3919	–0.0711	–0.6261	–0.1018	–0.1577	–0.2298	–0.4885	–0.4033
July	0.6983	0.6193	0.4875	0.4386	0.2237	0.3972	–0.7497*	1.1175
August	0.7091*	1.3989	0.6551	0.7598	–0.0464	–0.0761	–0.1179	–0.3288
September	0.8638**	0.6434	0.0420	0.0515	0.4873	0.7780	0.9632***	1.5825
October	0.6968	1.3882	–0.5818	–0.6406	–0.2030	–0.1007	–0.5670	–0.4719
November	0.288	0.2151	–0.0155	–0.0110	–0.1855	–0.0626	–0.0056	–0.005
December	0.9071**	0.7552	0.8601**	0.5376	0.7893*	0.4649	0.7420*	0.5496
Annual	–0.4062*	–0.1150	0.1890	0.0355	–0.0632	–0.0120	0.1777	0.0304
Average of 1978 and 1979; Corr. = 0.0061 Reg. = 0.0013					Corr. = 0.0787 Reg. = 0.014			

Significant differences are indicated by *(P ⩽ 0.05), **(P ⩽ 0.01) or *** (P ⩽ 0.001).

TABLE 2

CORRELATION AND REGRESSION COEFFICIENTS BETWEEN THE CAPTURES (LOG N+1) OF *M. striata* AND THE ATMOSPHERIC MAXIMUM AND MINIMUM HUMIDITY PARAMETERS

	Maximum Humidity (%)				Minimum Humidity (%)			
	1978		1979		1978		1979	
	Corr.	Reg.	Corr.	Reg.	Corr.	Reg.	Corr.	Reg.
January	—	—	–0.5363	–0.3825	—	—	–0.3640	–0.0287
February	—	—	–0.0803	–0.0164	—	—	–0.7379*	–0.0320
March	—	—	–0.7354*	–0.0837	—	—	0.0236	0.0009
April	–0.3924	–0.0714	–0.1373	–0.0411	–0.2665	–0.0095	–0.3558	–0.0607
May	–0.3131	–0.0573	0.3567	0.0972	–0.4411	–0.0267	0.8498**	0.2123
June	0.271	0.0149	0.8084*	0.0689	0.4972	0.0154	0.5936	0.0301
July	0.3086	0.1332	–0.2733	–0.0692	–0.8891**	–0.2083	–0.0460	–0.0460
August	–0.5684	–0.4599	–0.1663	–0.1104	0.6098	0.1607	–0.5582	–0.1478
September	–0.8020*	–0.4985	–0.6791	–0.5115	–0.9864***	–0.1380	–0.4632	–0.4632
October	–0.5435	–0.2769	–0.9747***	–0.557	–0.7342*	–0.1011	0.0822	0.0233
November	0.7076*	0.1430	–0.7944*	–0.0664	–0.0339	–0.0016	–0.7443*	–0.0353
December	0.6872	0.3002	–0.3196	–0.0642	0.1084	0.0231	–0.6003	–0.0618
Annual	0.4781**	0.1871	0.0361	0.0105	0.3079	0.0160	–0.0622	–0.0038
Average of 1978 and 1979: Corr. = 0.1806 Reg. = 0.0579					Corr. = 0.1006 Reg. = 0.0057			

Significant differences are indicated by *(P ⩽0.05), **(P ⩽ 0.01) or ***(P ⩽ 0.001).

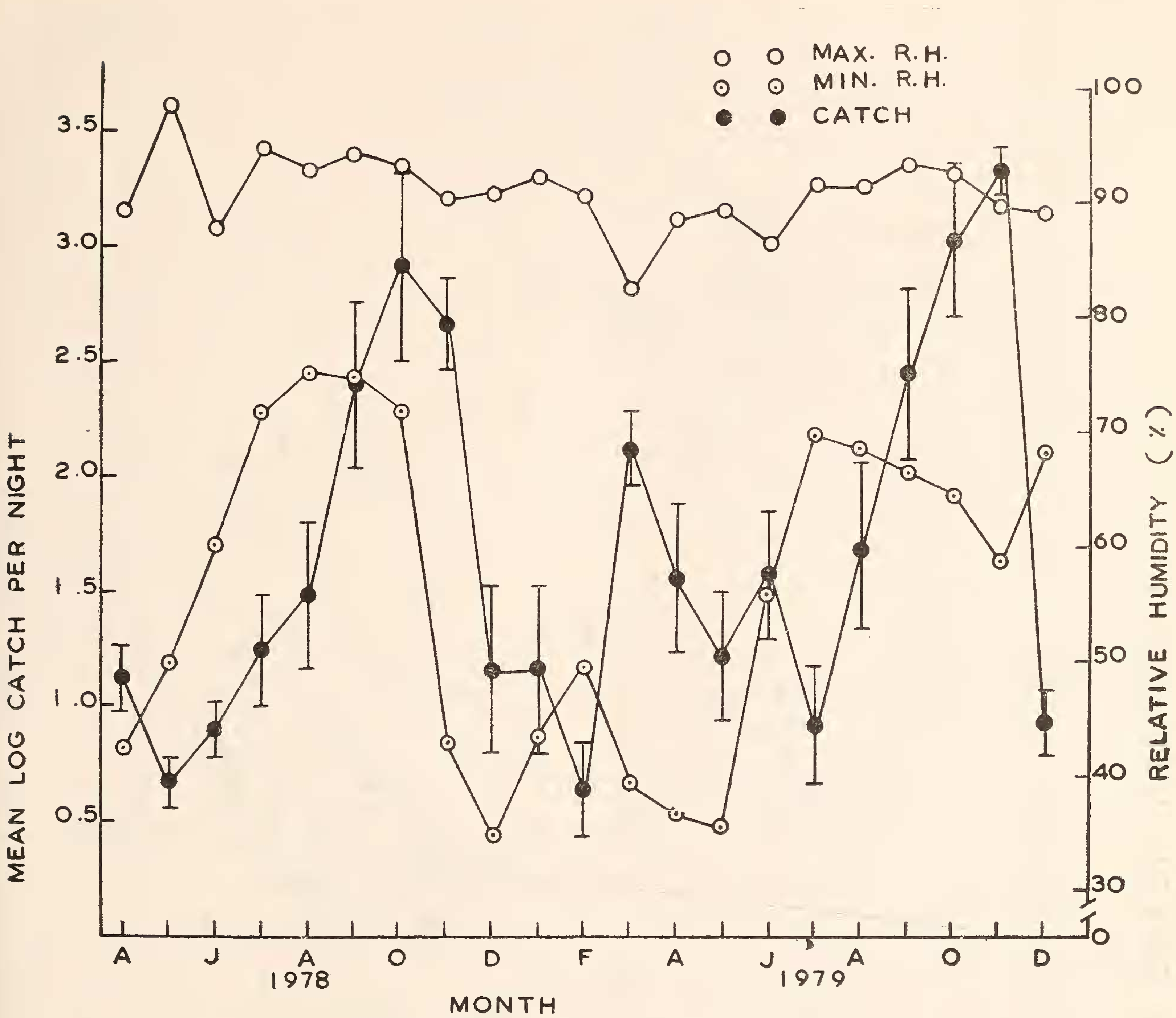

Fig. 5. Seasonal changes in abundance, as mean log catch per night, of *M. striata* against the corresponding changes in atmospheric maximum and minimum relative humidity (Vertical lines represent one standard error on either sides of the mean).

for 1978 and 0.0304 for 1979). The positive 'b' values for 1979 with both the parameters suggested that the average change of 8.5°C or 9.9°C in the respective atmospheric maximum and minimum temperatures would precisely be required for a unit change in the activity of the insect species.

Variations in activity in relation to relative humidity:

Figure 5 shows the seasonal changes in abundance of *M. striata* as mean log catch per night, in relation to corresponding changes in the moisture content of the air. It would be noted from the figure that the average mini-

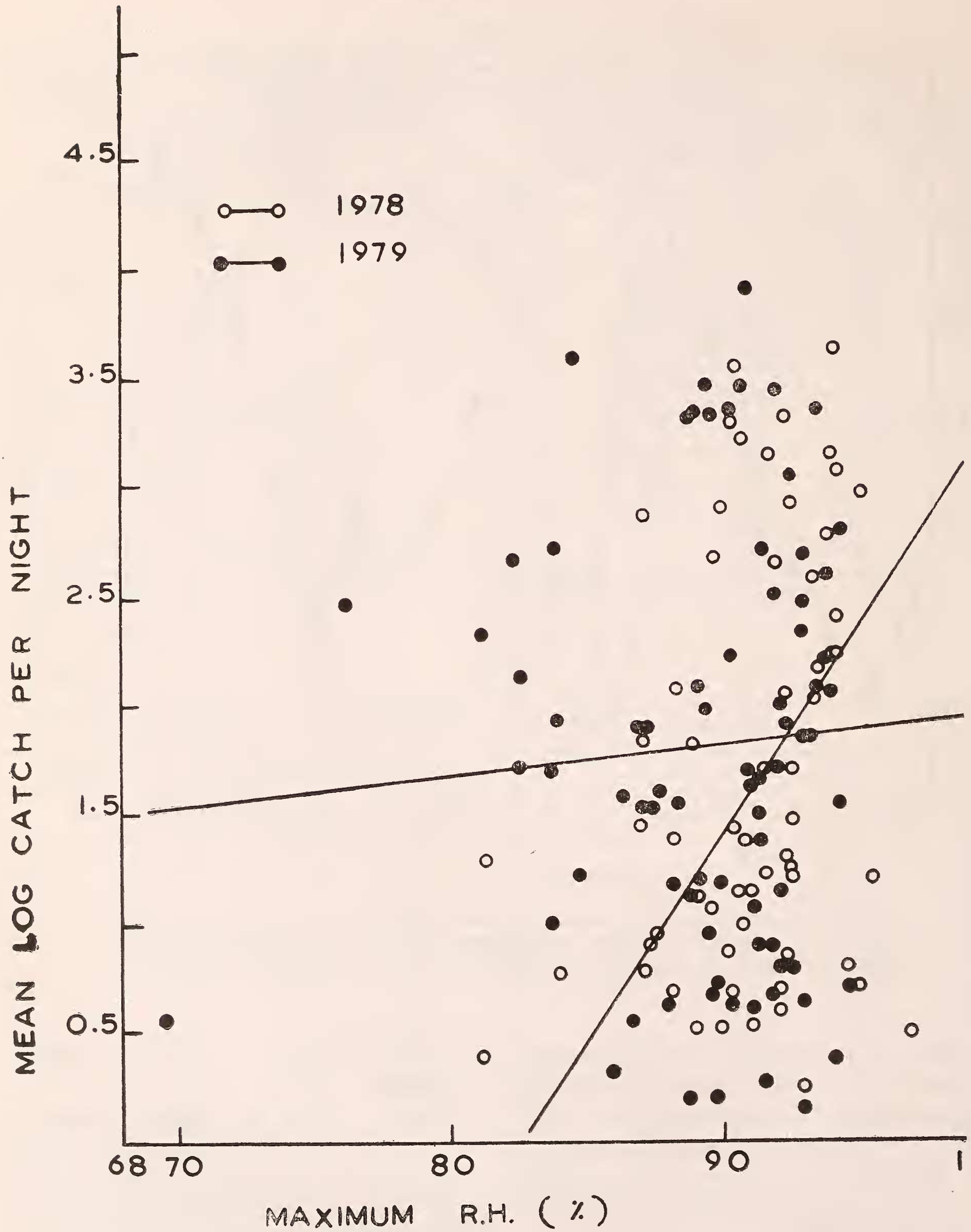

Fig. 6. Scatter diagram with regression lines showing relationship between the captures of *M. striata* and atmospheric maximum relative humidity (for 1978, Y = 0.1871 x − 15.419 and 1979, Y = 0.8717 + 0.0105 x).

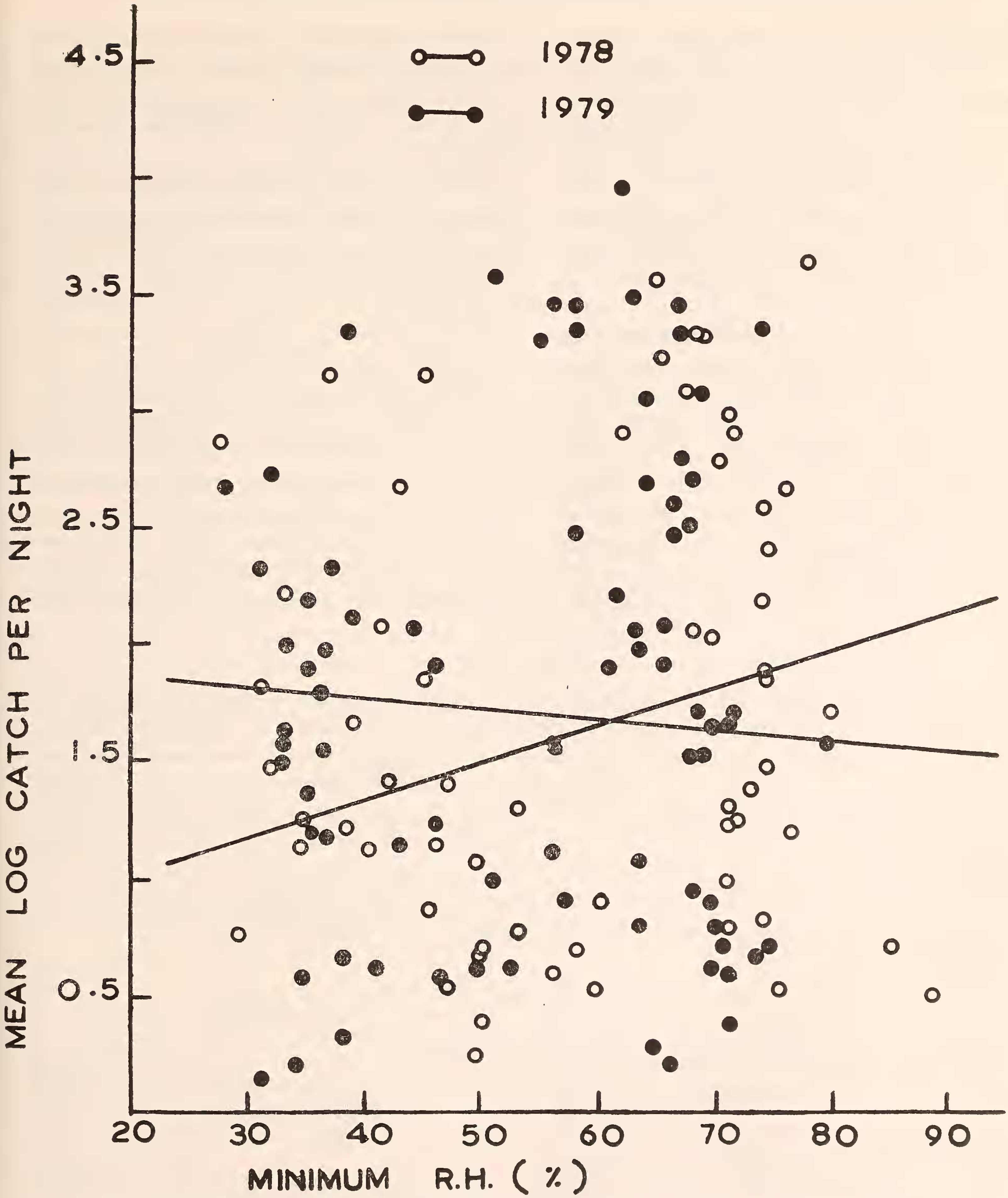

Fig. 7. Scatter diagram with regression lines showing relationship between the captures of *M. striata* and atmospheric minimum relative humidity (for 1978, Y = 0.6903 + 0.016 x and 1979, Y = 1.9246 − 0.0038 x).

mum relative humidity fluctuated violently (34.52%-74.46%) in contrast with that of the maximum one (82.55%-94.26%). Even then, the increases in local activity and abundance of the insect species during October 1978, and March, June and November 1979 were associated with the respective maxima and minima of local humidity parameters ranging from 92.57 to 71.6%, 82.55 to 39.17%, 86.36 to 55.9% and 89.7 to 58.7%.

Simple correlations with the maximum relative humidity indicated that these were significantly positive in November 1978, and June 1979; and negative in September 1978, and March, October and November 1979 (Table 2). Similarly, the 'r' values with minimum relative humidity were significantly positive in May 1979; and negative in July, September and October 1978, and February and November 1979. Besides, the average 'r' value for 1978 was significantly positive ($P \leqslant 0.01$) with maximum relative humidity; whereas, two years' average correlations were insignificantly positive with regard to both the humidity parameters.

Figures 6 and 7 indicate through scatter diagrams the linear relationship between the captures of the insect species and the humidity parameters. The regression constants with the humidity parameters indicated that the average changes of 1.6% or 28.8% in the atmospheric maximum relative humidity during 1978 or 1979, respectively and 18.9% in the atmospheric minimum relative humidity during 1979, would precisely be required for a unit change in the activity of the species population.

It ought to be evident from the above that the change in the activity of *M. striata* was somewhat influenced by the seasonal changes in temperature and humidity conditions of the

TABLE 3

ANALYSIS OF VARIANCE OF THE CAPTURES (LOG N+1) OF *M. striata* AGAINST THE ENVIRONMENTAL PARAMETERS (TABLE VALUES AT 5% AND 1% POINTS ARE 4.35 AND 8.10. WITH $f_1 = 1$ AND $f_2 = 20$, RESPECTIVELY)

Sources of variation	Sum of squares	Degrees of freedom	Mean squares.	Variance ratio (F)
Regression of max. temp.	0.0177	1	0.0177	0.0396
Residual	13.5074	20	0.6749 = 98.8% or 0.2% explained	
Regression of min. temp.	1.7346	1	1.7346	
Residual	11.7905	20	0.5895 = 87.18% or 12.82% explained	2.942
Regression of max. rh.	7.98	1	7.98	
Residual	5.5451	20	0.2772 = 40.99% or 59.01% explained	28.7878
Regression of max. rh.	2.8509	1	2.8509	
Residual	10.6742	20	0.5337 = 78.93% or 21.07% explained	5.3417
Total	13.5251	21	—	—

air. From the analysis of variance (Table 3), it may also be observed that a larger portion (80.08%) of the variations in the insect's activity was ascribed to the humidity parameters, particularly to the maximum one (59.01%), than that of the temperature parameters. The unexplained portion of the variations is ascribable to some other factors, such as rainfall, wind, food, etc. which are excluded from this purview.

Discussion

No matter what abundance and activity the light trap catches reveal, much of the representation of these catches in this paper is speculative because variations in the capture result from changes in the level of local abundance, and from the nature and extent of local activity induced by the prevailing environment (Bowden and Gibbs 1973, Banerjee 1977). It is, therefore, thought particularly useful to study the phenology of the species population that gives rise to the variations in seasonal captures in relation to the climatic conditions of the place.

Notwithstanding the source population, one trap at a single location was used to record events that involved variations in local abundance and activity of the insect species. The numerical change in abundance of the insect species between different times, as reflected by the light trap samples for all the seasons of the insect's activity, suggest its range of selective preference to the optimum environmental conditions.

Seasonal fluctuations in abundance and activity of insects depend on biotic as well as on climatic factors. The periods of large catches of the insect during September, October and November were related in some way to the prevailing local conditions of temperature and humidity. Temperature differences showed negative or indifferent correlation with the observed variations in the activity. Much of the variations (59.01%) in activity of *M. striata* was associated with the changes in the maximum relative humidity content of the air even though both of the influencing humidity parameters were considered for this study. This suggests that the insect, which is primarily an aquatic one, depends more on the moisture content of the air during night for its activity than on any weather factor; and slight alteration in such a parameter may induce considerable change in the activity of the species population.

Acknowledgement

We are thankful to Prof. D. K. Choudhuri for providing facilities to one of us (ASM) to work in the department.

References

Andrewartha, H. G. & Birch, L. C. (1954): The Distribution and Abundance of Animals. University of Chicago Press, Chicago.

Bailey, N. T. J. (1959): Statistical methods in biology. The English Universities Press Ltd. Lond., 200 pp.

Banerjee, T. C. & Choudhuri, D. K. (1980): Studies on the seasonal variations of the swarming of the males of *Dorylus labiatus* (Hymenoptera: Formicidae) in relation to some environmental factors. *Rev. Ecol. Biol. Sol. 17*: 217-227.

Beall, G. (1938): Methods of estimating the population of insects in a field. *Biometrika, 30*: 422-439.

Bigger, M. (1976): Oscillations of tropical insect population. *Nature*, Lond. *259*: 207-209.

Dobzhansky, T. & Pavan, C. (1950): Local and seasonal variations in relative frequencies of species of *Drosophila* in Brazil. *J. Anim. Ecol. 19*: 1-14.

Gibbs, D. G. & Leston, D. (1970): Insect phenology in a forest coca farm locality in West Africa. *J. Appl. Ecol. 7*: 519-548.

Owen, D. F. (1969): Species diversity and seasonal abundance in tropical Sphingidae (Lepidoptera). *Proc. Roy. ent. Soc.* Lond. (A) *44*: 10-12.

Popham, E. J. (1943): Ecological studies of the commoner British Corixidae. *J. Anim. Ecol. 12*: 124-136.

Pruthi, H. S. (1969): Text book on Agricultural Entomology. ICAR publication, New Delhi, India, 977 pp.

Williams, C. B. (1937): The use of logarithms in the interpretation of certain entomological problems. *Ann. Appl. Biol. 34*: 406-414.

——————— (1961): Studies on the effect of weather conditions on the activity and abundance of insect populations. *Phil. Trans. 224*: 331-378.

Wolda, H. (1978a) Seasonal fluctuations in rainfall, food and abundance of tropical insects. *J. Anim. Ecol. 47*: 369-381.

————— (1978b): Fluctuations in abundance of tropical insects. *Amer. Natur. 112*: 1017-1045.